AN ANALYSIS OF THE NAVY STOCK FUND

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Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE
IN
MANAGEMENT

United States Naval Postgraduate School
Monterey, California

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This work is accepted as fulfilling

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IN

MANAGEMENT

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ABSTRACT

Navy Stock Fund working capital reductions can be primarily attributed to vastly expensive but largely inactive safety stock maintained in a decentralized storage system. By tracing through a statistical method for determining the most economical quantity of safety stock to maintain, inefficiencies in attempting to provide equally high availabilities for all items of stock at local activities are pointed out that may well justify the working capital reductions.

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CHAPTER I

INTRODUCTION

1. The Concept

The Navy Stock Fund is technically a "pool of money appropriated from the General Fund of the United States and held on the books of the Treasury Department...."[1] This is rather like describing an iceberg as that small portion of a floating mass of ice that is visible above the surface of the water. Various categories of material that have been purchased from "the fund" would be hidden, like the submerged portion of an iceberg, by such a strict definition. These stores of materials just referred to are carried in a suspense account known as the Navy Stock Account until needed by consumer activities. Both the Navy Stock Fund cash and Navy Stock Account inventories combine to make up the working capital of a supply management concept that "represents an effort to provide room for business management within the framework of a military organization."[2]

The term "stock fund" has grown to also mean the supply concept--the structure, the cash, and the material inventories of this manage-

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[1]U.S., Navy Department, Bureau of Naval Personnel, Financial Management in the Navy, Navpers 10792-A (1962), p. 178.

[2]Arthur Smithies, The Budgetary Process in the United States (New York: McGraw-Hill Book Company, Inc. 1955), p. 316.

ment innovation. It is to the management of the total working capital that this paper is directed.

A stock fund can, perhaps, best be described as a revolving fund that finances a cycle of operations involving the purchase and sale of an inventory of supplies. "The principal followed in the conduct of stock funds is similar to commercial enterprise, except that there is no sales promotion, and operations are conducted on a break-even basis."[3] It might be added that no sales promotion is required because the fund is selling to a captive market, and there is generally only an approximation to break-even operations.

Figure 1 depicts the revolving concept of a stock fund in general. Common items of material are purchased with the fund's capital by stock fund managers and distributed to the consumers through established supply channels. Appropriations are granted annually by the Congress as a means for the consumers--bureaus, offices, operating forces, etc.--to carry out approved programs and activities. Upon withdrawal of supplies from the Navy Stock Account to accomplish such approved programs and activities, the annual appropriations of the customers are charged and the capital of the fund is reimbursed. Funds generated in this manner are used to procure additional inventory for the fund and complete a

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[3]U.S. Navy Dept., Financial Management, p. 178.

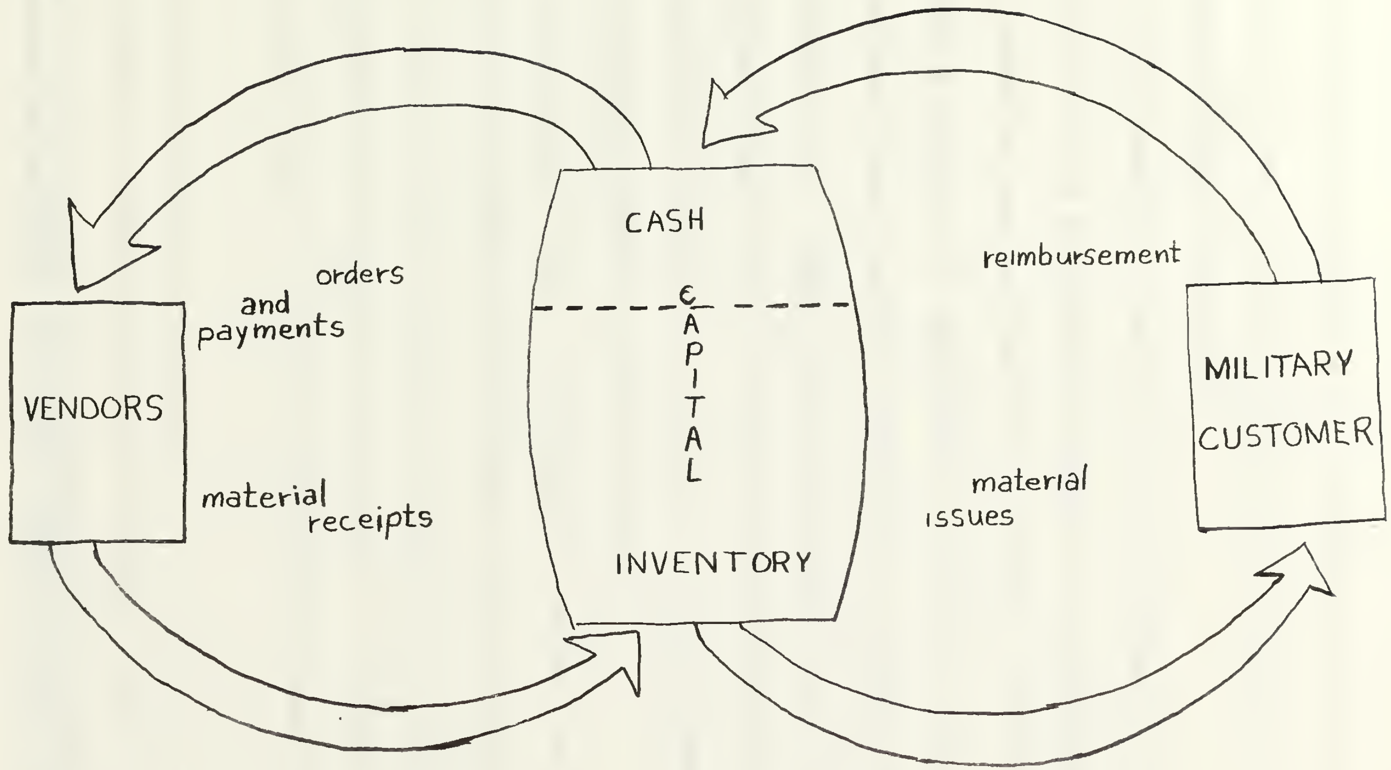

Figure 1

THE REVOLVING CONCEPT OF A STOCK FUND

cycle of operations. Thus, the conversion of stock fund cash to inventory, the sale of inventory to a customer, and the reimbursement of stock fund cash by annual appropriation, in theory if not in fact, perpetuates the Navy Stock Fund.

The only practical alternative to stock funds, if supplies and materials are to be available when needed, is a "free-issue" system. Such a system was used exclusively by the Army and Air Force prior to the National Security Act Amendments of 1949[4] and still applies to the bulk (at least from a monetary standpoint) of supplies held by each of the services today. Under this system, supplies are purchased initially with end-use funds, carried in supply systems until required, and issued with "statistical" charges to consumers. The Navy labels such stores as Appropriation Purchases Account material.

Various writers, bent on governmental reform, have pointed out the diseconomies associated with free-issue systems in the military departments. Abba P. Lerner, an eminent economist, once proposed that the whole military establishment be organized in a network of markets that would operate much as the American economy.[5] Theater commanders would

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[4]U.S., Title IV, Public Law 216, 81st Congress, dated 10 August 1949.

[5] Abba P. Lerner, Design for a Streamlined War Economy (Unpublished Professional Paper, Amherst College, Amherst, Mass., 1942).

be granted allocations of money based upon the relative military worth of their commands. They in turn would "bid" for the various supplies and men with various skills would be adjusted according to the demand for them. In this manner, the relative usefulness of various instruments and skills could be determined for the supply managers and training commands. It was contended that these actions and interactions would lead to a more efficient use of resources.

As Charles J. Hitch and Roland McKean point out, stock funds are but a "piecemeal approach" to Lerner's proposal.[6] These authors, while commenting on both the advantages and possible shortcomings of stock funds, conclude that "the functioning of funds, like that of private enterprise, does not have to be perfect in order to be more efficient than alternative arrangements.[7]

2. The Problem and Method of Study

The early success of the Navy Stock Fund in managing ordinary commercial supplies is well known. Congress was so impressed with the results of the Navy's stock fund operations that it granted the Secretary of Defense authority in 1949 to direct the use of stock

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[6]Charles J. Hitch and Roland McKean, The Economics of Defense in the Nuclear Age (Cambridge: Harvard University Press, 1963), p. 224.

[7]Ibid., p. 226.

funds for financing inventories throughout the Department of Defense.

The Navy Stock Fund was expanded in 1957 to include technical repair parts. With these spares came an obsolescence problem, and annual operating losses have been the rule rather than the exception since that time. Congressional recissions in recent years and the establishment of the Defense Supply Agency in 1961 have also had a considerable impact upon the fund's operating capital.

The limitations of working capital have posed many problems upon the Navy Stock Fund managers. Reduced procurement allotments mean that supplies must be ordered in smaller quantities and oftener, and such increases in workload must be met with a stable work force. Shortages in procurement funds also mean a reduced availability of stocks to meet variable demands and a curtailment of outfitting plans for new programs.

This study has attempted to determine, through a review of various manuals, instructions, professional papers and the like which are available in the library of this school or through informal sources, the central issue of the current funding problem.

The approach taken in this paper was to (1) examine Department of Defense and Navy Department policies with regard to Navy Stock Fund inventory problems, (2) determine a focal point for managerial action, and (3) suggest a possible approach to the problem uncovered.

3. Assumptions

It is assumed that obtaining adequate working capital to resolve Navy Stock Fund financial problems through budgetary channels is not possible under present conditions. The following comments by the Comptroller of the Bureau of Supplies and Accounts indicates this to be the case:

> The rapid decline in cash was anticipated and efforts were made during the past year to obtain cash augmentation both through the appropriation process and by readjustment of cash among the services and DSA stock funds. OSD is aware of the problem, but has provided only limited cash relief...The failure to restore NSF cash to previous levels is no isolated action within DOD, but only the manifestation of a basic OSD policy to reduce all working capital funds to a bare minimum. It is now apparent that we are expected to manage the fund with a minimum cash balance.[8]

It is further assumed that current pricing policies for Navy Stock Fund material are reasonable and that break-even prices for stocks subject to a high obsolescence risk would be impractical. Research revealed that the pro's and con's of our current policies on this subject have already been thoroughly covered. The Department of Defense policy on pricing is quoted:

> ...surcharge rates should be established to include potential losses on all current purchases...in addition,

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[8]H. H. Hunt, "A New Dimension of Management in the Navy Stock Fund," (Bureau of Supplies and Accounts Monthly Newsletter, May 1963), p. 11.

> in event a surcharge rate would be unreasonably high because of high estimated potential losses on current procurement of mobilization reserve stocks, it will be permissable to establish a reduced charge rate for each category or class to be established shall include, as a minimum, estimated future losses on current purchases of operating stocks.[9]

It has been estimated, however, that surcharge rates in excess of 90% would be required to compensate for obsolescence in some segments of material. One writer concluded recently that:

> The present method of establishing surcharges for obsolescence is a compromise. The standard price includes a factor applicable to an entire category of material and is normally applied only to those items procured for peacetime operating stocks. Unofficially, the fear of excessive prices has established a limit of 15% for all surcharges. All ships and Naval activities have some local procurement authority and must have. If the price of an item is higher than the price for the same item from a commercial source, the temptation to purchase locally is inversely proportional to the availability of operating funds.[10]

This assumption is not that the obsolescence problem in Navy Stock Fund inventories should be ignored. If anything, the problem of obsolescence should be brought out into the open more than it already has been. Obsolescence is a relatively hidden cost in APA stocks. No doubt many decisions have been made to make marginal improvements in equipments, without due consideration of the effect on currently

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[9] U.S. Department of Defense, "Regulations Governing Stock Fund Operations," DOD Directive 7420.1 of 19 December 1956, p. 11.

[10] Robert D. Fisher, The Navy Stock Fund (Unpublished Master's Thesis, George Washington University, Washington, D.C., 1962), p. 43.

held spares. Purging APA stocks of such excesses is then termed good inventory management. In the Navy Stock Fund, it would be an operating loss and receive considerably more management attention.

4. Limitation of the Study

The subject of military essentiality has been carefully avoided throughout this paper. There can be no question that economic considerations alone should not govern our inventory policies. Military essentiality, however, is a subject beyond the scope of this paper.

CHAPTER II

RECENT DEVELOPMENTS

1. General

> And the Secretary of the Treasury is hereby authorized and directed to cause general account of advances to be charged with the sum of two hundred thousand dollars, which amount shall be carried to the credit of a permanent naval supply fund to be used under the direction of the secretary of the Navy in the purchase of ordinary commercial supplies for the naval service, and to be reimbursed from the proper naval appropriations whenever the supplies purchased under said fund are issued for use.[1]

It is not the purpose of this paper to describe the history of the Navy Stock Fund since its establishment in 1893. Such efforts would be trite since several articles and papers have already been written on this subject from a historical and legislative point of view.[2]

It is deemed necessary, however, to briefly summarize several historical developments of the past few years that have affected stock fund operations to a considerable degree.

2. Congressional Recissions

One of the features of the stock fund concept that has impressed Congress is the ease with which they can control the overall investment

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[1]U.S., 27 Stat. 723, Act of March 3, 1893

[2]See History of the Navy Stock Fund and Naval Stock Account, 1945 Bureau of Supplies and Accounts, Navy Department, Washington, D.C. (mimeographed)

levels of Navy Stock Fund inventories. Congress has certainly used this feature in the recent past. Congressional recissions totaled 1.3 billion dollars from 1954 to 1963.

Many of the earlier diversions of cash were no doubt justified. The Navy emerged from the Korean conflict with large excesses of stock fund material. During this time there were also advancements in inventory management techniques, and large numbers of stock points had mechanized their stock records.

The capitalization of repair parts in 1957 also generated surplusses that caught the eye of Congress even though some operating losses were apparently caused by these transfers. One writer states:

> The capitalization of repair parts inventories had the immediate affect of generating surplusses and items, in long supply. Even though these materials had been subject to Navy-wide reporting and centralized inventory management...there had been no compelling reasons to eliminate the surplusses that existed. Storage space was available and the materials were paid for. They represented [illegible] operating and capital assets which could be utilized to supplement funds. Upon capitalization into the Navy Stock Fund, they became subject to the revolving fund concept. These stocks, if not active, reduced the efficiency of the system and it was no longer economically feasible to retain them. Hence many were declared excess and sold. The losses were absorbed by the fund.
>
> Congress, on the other hand, apparently felt that, in spite of these losses, the money which had been appropriated to purchase these materials originally should be returned to the Treasury or made available for other uses by reappropreation. The net result is that today the supply of a considerably greater number of items has to be financed with less capital.[3]

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[3]Fisher, op. cit., p. 34.

More recently, however, recissions have been initiated by the Department of Defense to secure monies for other programs. The operating capital of the fund is, no doubt, now competing with the alternate uses to which such funds can be placed.

3. Extensions of NSF Coverage

Available evidence points to the fact that the extension of Navy stock Fund coverage into the area of spare parts was done with considerable deliberation and care. Planning for the expansion dates back to the post-World War II days.

> Following World War II, a comprehensive study of the entire Navy supply system was inaugurated, based on World War II experience. The recommendations of those making the study were incorporated in a document known as the Navy Supply Plan.
>
> The Navy Supply Plan proposed a single fund procurement as the most efficient method of obtaining and maintaining replenishable stocks...
>
> The Navy Stock Fund and Navy Stock Account had all the essentials of such a single fund and single account, but the plan was never fully implemented in this respect.[4]

Department of Defense policy at that time provided the following broad guidelines with regard to authorized inclusions of coverage for stock funds:

> 1. All material procured and/or stored for supply purposes. This is intended to include all consumable types of material

[4]John W. Hempstead, "A Study of the Navy Stock Fund, 1893-1952" (Unpublished Master's Thesis, The American University, Washington, D.C., 1953), pp. 115-116.

> and relatively minor items of equipment, including parts and components used in the manufacture, assembly, maintenance or rebuild of end-items for the military supply system. The term "consumable" material is used in the sense of covering all material which may be considered to be expended to operating and maintenance appropriations when withdrawn from stock funds for use. However, no hard and fast definition may be drawn.[5]

An "Ad Hoc Committee to Examine Methods and Procedures for Material Requirements Determination and Budgeting Therefor" also recommended in 1955 that the Navy Stock Fund be extended to APA repair parts inventories.[6] This committee pointed out that all the items to be included were not necessarily subject to rapid turnover and that rate of stock turn was not an adequate criterion to measure the effectiveness of the stock fund for such items.

Authorization was obtained and the decision was made to transfer repair parts to the Navy Stock Fund effective 1 July 1957. Since that time, operating losses because of increased obsolescence have had a pronounced effect upon the operating capital of the Navy Stock Fund.

4. The Defense Supply Agency

The establishment of the Defense Supply Agency in 1961 had a very profound effect upon the Navy Stock Fund, both from a financial and

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[5]U.S., Department of Defense, "Principles to be Observed in Determining Material to be Included in Stock Funds," DOD Instruction 7420.5 of 26 November 1956.

[6]Fisher, p. 29.

an operational viewpoint. DSA assumed the responsibility for procurement and supply management for a considerable number of repetitive demand-type items which are used by two or more of the services. These items that are purchased and held by DSA are termed wholesale stocks. The individual services use their own funds (Navy Stock Fund or end-use appropriations) to obtain commodities from DSA. Items that are purchased with NSF monies and placed in the Navy Stock Account are termed retail stocks.

This transfer of cognizance reduced the number of items over which Navy ICP's exercised the inventory control functions by about one half. For those items that were transferred to the Defense Supply Agency control, the Navy no longer has inventory control points to conduct supply demand reviews, to "push" materials to stock points and relocate system stocks or to direct the disposition of excesses. These functions for DSA managed items fell on the relatively unprepared shoulders of supply departments at activities throughout the supply system.

Both cash and inventories were required to be transferred to the newly established Defense Stock Fund in 1962 and 1963. The transfer of cash was, of course, a direct loss of procurement funds. The transfer of inventories not only reduced the corpus of the Navy Stock Fund but also eliminated the prospects of cash generations from the sale of these formerly Navy owned assets.

Following the changes mentioned was a rather severe reduction in the inventory investment allowed at Navy stock points. Activities stocking a significant amount of materials in the various DSA commodity groups were granted specific Navy Stock Fund allotments for the procurement of DSA materials.

The following is a summary of the situation created at local activities by these various changes:

> Navy Stock Funds are parceled out by BuSandA to the Navy Retail Offices (FMSO, NSO, NC&TO, ESO, FSO). The NRO's establish broad guidelines which include the maximum requisitioning objective, maximum operating level, safety level, and funded investment level. The former two can be locally decreased and the latter two cannot be changed in any manner. The safety level (for CONUS activities) is one month and the funded investment level is $2\frac{1}{2}$ multiplied by the average monthly money value of issues...
>
> The rationale which establishes the funded investment level is based on a five-month requisitioning objective. This would yield a maximum on hand stock position (stockage objective) of four months (immediately upon receipt of an order) to one month (immediately prior to receipt of an order). Theoretically, on hand balances will vary from one month to four months for an average on hand stock level of $2\frac{1}{2}$ months. Funds are granted on this basis.[7]

As might be expected, demands do not always behave the way the theoretical sawtooth inventory models would depict them. Demands for

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[7]L. W. Gorenflo, "The Challenge of Local Inventory Control" (Bureau of Supplies and Accounts Monthly Newsletter, August 1964), p. 14.

some items that were stocked failed to materialize and there were requirements to stock "new" items on the basis of recorded demand. At an activity operating on a fixed-month requisitioning objective for all items of stock, as many manual activities were, decreasing the requisitioning objective for all stocks to release funds for other purposes would greatly increase the ordering workload. It can be shown mathematically in such cases that to decrease the investment in stocks by 20% requires 50% increase in the number of orders placed. This situation, no doubt, greatly increased the interest in scientific inventory management.

5. Variable Stock Levels

Although economic order quantity formulas have been utilized at ICP's and major stock points for some time, the recent development of a Variable Stock Level (VSL) program by the Fleet Material Support Office[8] for use at mechanized supply activities appears to be the most notable recent achievement in this area, since it provides a great number of lesser stock points with a tool to maximize their supply effectiveness.

The VSL program appears to have incorporated practically all the latest theoretical innovations of scientific inventory management and

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[8]U.S., Navy Department, Navy Fleet Material Support Office, Variable Stock Level Program (Preliminary Draft) 1 July 1964 and EAM Version (Preliminary Draft) 1 September 1964.

coupled them with the practical aspects of "the real world."

The VSL program makes no attempt to reduce the total variable costs of inventory control by equating the variable costs to order with holding costs. This appears to be very practical since almost all of the variable costs to order are made up of salaries. The program, in effect, assumes a constant personnel ceiling and allows each activity to choose a reasonable number of orders that can be placed under this fixed workforce. The advantages of decreased inventory investments are gained by mathematically computing the "correct" number of months of stock to carry for individual line items based upon their annual monetary demands within the constraint of a fixed annual number of orders to be placed.

Another feature of the VSL program is thatthe mathematical formulas to compute optimum stocking rules are tailored to the individual activities. This may be an unnecessary refinement if there is no great variation in the characteristics of inventories throughout the system. Tailoring the program does, however, require an annual recomputation of each individual activity's program. From this standpoint, the individual tailoring is extremely beneficial for control purposes. It is an accepted fact that any control device must receive feedback and be able to make adjustments if it is to be effective.

The FMSO VSL program can be considered a significant step forward

in selective item management. It is designed to get the most out of every procurement dollar under current budgetary constraints. Good as it is, however, it does not help to get additional procurement funds or to justify retention of present safety levels of slow-moving stock. Unfortunately, too, it does not assist those manual supply activities hit hardest by recent developments.

CHAPTER III

1. The Central Issue

There are numerous problems that are present in Navy Stock Fund operations. Many of these problems seem so interrelated that it is difficult to single out any particular one and examine it closely. The range of items to be covered by the fund, for example, has always been a problem. If parts are not stock funded and are required to be on hand when needed, they are procured and carried as Appropriation Purchases Account material--the so-called free-issue system. The Navy is then criticized for waste that results from the lack of any incentives to restrict the use or hoarding of these items. If these particular parts are included in the Navy Stock Fund, obsolescence rears its ugly head and the revolving concept of the fund is threatened. It has been shown that it is virtually impossible to recover expected obsolescence losses through a break-even pricing policy. Such a policy would reduce the buying power of the fleet and create a strong need for additional operating funds in that area. Also, if such items do not maintain an adequate stock turn ratio, there is pressure exerted from DOD to reduce the inventory investments.

It has become apparent to the writer that most of the Navy Stock Funds' financial problems can be attributed to the vast amount of

investment required in safety stocks, particularly for insurance items, to maintain a high degree of material availability in locations near consumers.

It is an established fact that most categories of stock fund material are composed of only a few items that are subject to rapid turnover. The majority of items have low demand rates and relatively unpredictable demand patterns. As a result, the inventory investment that is required at each supply activity to maintain a high degree of stock availability is tremendous.

In a rather cogent article--centered around the costs of providing logistics support--Commander H. F. Mills, SC, USN, a frequent contributor of professional articles in the field of supply management, analyzed the stock levels, in terms of months of supply, necessary to provide various levels of availability for a group of slow moving Navy Stock Fund repair parts.[1] Actual demand data for a sample of 100 of these insurance type items was taken from the records of the Ships Parts Control Center, a Navy Inventory Control Point. The average demand for each of the items in the sample was one unit per quarter. Commander Mills computed that a three months supply of stock (as

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H. F. Mills, "Uncertainty in Logistics" (Bureau of Supplies and Accounts Monthly Newsletter, May 1963), pp. 7-10.

measured by average monthly usage) for each of these items provided only a projected 36% availability for the demand distributions involved. Twelve months of stock for each item provided only 82% availability and 18 months' worth of stock would be required to provide a 95% availability goal.

Commander Mills purpose in writing this particular article was apparently twofold. First, he pointed out the fallacy of planning, stocking, and budgeting in terms of weeks or months of supply for a large number of items currently carried in inventories. Second, he attempted to show the merits of a performance (in terms of supply availability) vice a conventional procurement budget. This writer agrees completely with the first point and also agrees with the concept of the second. His statement regarding 18 months of stock for these items of low demand that "the budget-preparing activity knows from experience that this is what it takes"[2] does seem rather heroic. Given an administratively assigned 95% availability goal, Commander Mills is correct. The point is, however, that we do not know on a rational basis how sound such a goal really is.

Perhaps some additional feeling for the problem of attempting to provide a very high availability of spare parts for a myriad of

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Mills, op. cit., p. 10.

equipments can be gained from the following:

> Nowadays, when a new ship slides down the ways, much of its equipment is already obsolete in terms of another ship still under construction, and, to further complicate the problem, whole equipments and systems installations are replaced on commissioned ships, during and even between shipyard overhauls, in a continuing race to stay abreast of exploding weapons technology.
>
> The resulting conglomeration of equipments provides a "messy" support problem. For example, in one category of material (installed machinery), the Ship's Parts Control Center maintains allowance parts lists for 110,000 different equipments. 46,000 of these lists provide itemizations of repair part support for equipments which are installed on only one Navy ship. 75,000 of these lists are applicable to equipments which are installed on 4 or less ships.
>
> Viewed from another angle, in terms of individual repair part items, some 95% of the ordnance repair parts in the system have application in only one navy equipment (although that equipment may be installed in more than one ship).
>
> If we contrast this situation with that of the Air Force, where aircraft production runs are usually in the hundreds or thousands and the number of different types of aircraft in operations at any one moment in time is relatively small, we get some idea of the uniqueness of the Navy problem. And the problem can only get worse. Ships will get fewer. Technological change will occur even more rapidly, and equipment "useful lives" will grow shorter. Along with these changes, it is safe to assume that more complex equipments will require more numerous and more expensive repair part items to achieve a given degree of operational readiness.[3]

Lenz goes further to suggest that our supply system may not be operating as efficiently as it should be.[4] Specifically, he deals

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[3]A.J. Lenz, "Is the Waterfront Supply Depot Obsolete?" (Unpublished Research Paper, Stanford University, 1965), p. 3.

[4]*Ibid.*, p. 1.

with a comparison of the present decentralized storage policy for some 400,000 insurance-type repair parts versus a hypothetical central storage policy. No doubt there are now many items within the 400,000 that would prove to be more efficiently administered through a central depot. As the speed and service of communication and premium transportation facilities improve and as the costs for such services decrease, we should find an increasingly convincing argument for more central storage with its inventory reduction implications. Among the indicators of inefficiency that Lenz discovered are the following:

1. There are 1.65 demands generated within the mass of spare parts for every issue that is made--perhaps evidence that a great deal of the supply system's effort is to support itself. One would certainly expect that the number of demands would at least approximate the number of issues in a decentralized system. The .65 differential in these two figures indicates a relatively low success rate in satisfying demands at the first stock point tried--in fact, such point-of-entry availabilities were computed to range from only 60% for 1N cog material to 68.9% for 1A cog material.

2. There was an issue/receipt ratio of only 2.87; i.e., this whole segment of the supply system makes only 2.87 issues for each receipt transaction. This indicates that there must already be a large number of single item shipments--a rather startling fact when considering that our decentralized storage policies are based, at least in part,

upon the economies of scale in the transportation of material to a position near consumers. The statistics also reveal that approximately one third of the total issues involved are to "other Navy activities" and do not necessarily involve an issue to the ultimate user.

Such statistics must be tempered by the fact that stock fund procurement authorizations have not been what we would have desired the past few years. It seems fair, however, to assume that carryovers of inventory from the "good old days" provided larger stocks of these items than the budgeteers would be currently willing to finance. The point that these statistics can only get worse as the funding gap widens and an economic analysis of our stocking policies seems to be indicated that could justify our position or change our attitude.

The funding implications of our administratively assigned inventory service goals (more recently these have been determined solely by budgetary constraints) can rightfully be questioned.

Service levels in the past have been administratively set. Many writers on the subject of inventory control state that this is probably the best approach. Most conclude that it is the responsibility of management to administratively determine the level of service, tempered by the cost, that it desires to offer. Perhaps this is a good approach in the commercial world where competition and industry standards set a floor on service policies. In the Navy Stock Fund, however, it leaves

something to be desired. There are no industry standards and no competition to serve as a benchmark for the budgeteers that approve funding plans.

> ...Resources are always limited in comparison with our wants, always constraining our action. (If they did not, we could do everything, and there would be no problem of choosing preferred courses of action.) As a consequence, resource limitations are often called constraints. We try to achieve the most desirable outcome that is possible in view of these constraints.[5]

It should be obvious by now that the Department of Defense and Bureau of the Budget analysts place little worth in administratively assigned inventory service goals. At least the current funding policies for the Navy Stock Fund indicate that they do not. Put another way, it appears that we must reevaluate how much safety stock we can actually justify on the basis of the item characteristics. We must also be able to justify economically where these stocks are placed.

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[5]Hitch and McKean, op. cit., p. 23.

CHAPTER IV

AN APPROACH TO THE PROBLEM

> ...To help predict the consequences of alternative policies and practices, we may use models on paper, models in our heads, models in the form of games, or simulation laboratories to represent the functioning of logistics systems. In any event, the alternatives should be considered in terms of an economic criterion.[1]

It appears that if the Navy Stock Fund managers are to ever reverse the trend of reductions in working capital, some method of determining the most economic safety levels of stock for every supply activity in the whole system must be developed. Research reveals that several methods of determining least cost stocking policies have been propounded by various authors in the fields of statistics and mathematics.[2] Of these the techniques of Robert Schaffer, a subjective statistician, are the easiest to comprehend by this writer and will be explored somewhat in an attempt to determine the adequacy of current procedures for establishing safety levels of stock.

All of these methods require that the inventory manager know something of the demand distribution for each of the items in an

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[1]Hitch and McKean, op. cit., p. 281.

[2]See James W. Pritchard and Robert H. Eagle, Modern Inventory Management (New York: John Wiley and Sons, 1965) for a mathematical approach.

inventory--the probability that various quantities of an item will be demanded. A number of techniques have been developed to give the inventory manager this capability at mechanized activities so we will assume that this poses no great problem.

Another requirement for utilizing these least cost methods is some knowledge of two cost parameters--the costs that are incurred if an item is not available when we need it (shortage cost) and the cost that is incurred if too much stock is carried over lead time (cost of overage). It is the inability of inventory managers to estimate these cost parameters accurately that has apparently prevented even the consideration of least cost safety levels in the past. The writer will suggest later how we might overcome some of these difficulties.

For the benefit of readers not familiar with Schlaifer's techniques, and to emphasize some relationships for those who are, a simple example of his methods will be presented. Lead time--the time required to receive stock after an order is placed--will be assumed to be a constant of one month in this example to simplify the presentation.

It might be added that the writer envisions the use of these methods only in establishing reorder points for fast moving items and safety levels for insurance stocks at each echelon of the stock fund distribution system. Various EOQ methods are considered to be the best approach to establishing "correct" order quantities for the "operating" portion of stocks.

1. Incremental Analysis and Probability

The technique of combining incremental analysis with probability theory requires the use of the concept of expected value (or expected loss). The definition of expected value is given below. Its meaning should become clear from an example that is to follow.

> ...Expected value of an act: a weighted average of all the conditional values of an act, each conditional value being weighted by its probability.[3]

Let us assume that we are dealing with an item that has a unit cost of $10.00 and we have determined that four months stock is an economic order quantity. It will also be assumed that the shortage cost per unit is $1.50 and the cost of overage is $.50 per unit. Table I shows the hypothetical demand history for this item of inventory.

A decision on reorder point levels can be analyzed incrementally by thinking of the decision as being the result of not a direct choice of providing 80% or 90% service, but as a result of a whole sequence of decisions, each of which increases the stock level by one unit. The principal followed is to decide whether the first unit should be stocked. If it should, then the second unit is analyzed. The whole

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[3]Robert Sclaifer, Introduction to Statistics for Business Decisions (New York: McGraw Hill Book Company, Inc., 1955) pp. 25.

Table I

Sample Demand Distribution

for an Inventory Item

Demand Z	Probability of Z P(Z)	Probability that demand is less than Z $P(\bar{Z} < Z)$	Probability that demand is equal to or greater than Z $P(\bar{Z} \geq Z)$
0	.05	.00	1.00
1	.10	.05	.95
2	.20	.15	.85
3	.30	.35	.65
4	.20	.65	.35
5	.10	.85	.15
6	.05	.95	.05
7 or greater	.00	1.00	.00
	1.00		

range of possible quantities is examined in serial order until the point is reached where it costs more to stock one particular unit than it does not to stock it.

To find the costs that we would expect to incur if we do not stock the first unit, we multiply the probability that the demand will be greater than or equal to one unit (.95) by the expected cost of not stocking that unit ($1.50). The result of a decision not to stock the first unit would be an expected cost of $1.43. Similarly, if we multiply the probability that less than one unit will be demanded (.05) by the cost of overage for that unit ($.50), we find that the expected cost if we do stock the first item is only $.03. Obviously, we should stock at least one of these items since our expected cost is less if we stock than it is if we do not.

We now multiply the probability that demand will be greater than or equal to two units (.85) by the shortage cost and get $1.28 for an expected cost of not stocking the second unit. The expected cost if we do stock the second unit is .15 times $.50 or $.08. We should also stock the second unit.

We continue making computations through the fourth unit and find that it is still advantageous to stock that unit.

For the fifth unit, the probability of demand being greater than or equal to five units is only .15. Multiplying that probability

by the shortage cost, we arrive at an expected cost of $.23 if we do not stock the fifth unit. The probability that demand will be less than five (.85) times the cost of overage yields an expected cost of $.43 if we do stock that unit. Since the expected cost of stocking is greater than the expected cost of not stocking, it is not profitable to stock the fifth unit. Only four units of stock over lead time can be justified on economic grounds.

Computations for the entire example are shown as Table II. The reader will notice that the total expected loss of stocking the first four units ($.03 + $.08 + $.17 + $.33) plus the expected loss of not stocking units five and six ($.23 and $.08) is smaller than for any other combination of stock/do not stock possibilities.

An observation of columns three and five of Figure 2 will also show that each successive expected cost of net stocking is smaller than the preceding one and each successive cost of stocking is greater than the preceding one.

It would be difficult to compare the results of our computations with all the current procedures for computing reorder points. The FMSO VSL program, for example, utilizes the annual dollar demand of an item along with deviations in unit demand and lead time to compute reorder points. At manual activities, however, reorder points and safety stocks are currently based upon average monthly unit demands.

Table II

Expected Costs of Not Stocking

versus

Stocking Decisions

J	P(Z ≥ J)	\$1.50 x P(Z ≥ J)	P(Z < J)	\$.50 x P(Z < J)
0	1.00	\$1.50	.00	\$.00
1	.95	1.43	.05	.03
2	.85	1.28	.15	.08
3	.65	.97	.35	.18
4	.35	.53	.65	.33
5	.15	.23	.85	.43
6	.05	.08	.95	.48
7 or more	.00	.00	1.00	.50

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The average monthly demand for the item represented by Table I can be computed to be three units per month. At manual activities this would mean that the reorder point would be established at six units--three to cover expected demand over lead time and three for safety stock. The four unit reorder point in our example is composed of three units to cover expected demand and only one unit of safety stock.

Of course we would expect that safety levels would also increase for some items if warranted by economic considerations and the demand distribution. Safety levels of stock would be reduced for items with a relatively constant demand and increased for stocks with extreme variances in demand. Those factors, however, would be tempered considerably by the relationship of shortage costs to the costs of overage.

Whether the overall investment in safety stocks would increase or decrease and to what extent is not really the criterion that should be used in evaluating the worth of incremental analysis in setting reorder points and safety stock levels. The important point is that safety levels would be established on a rational and economic basis. If realistic cost estimates of shortage costs and overage costs can be made, then we would expect a safety level policy based upon incremental analysis to be the least costly policy in the long run.

2. The Critical Ratio

It must be admitted that it would be impractical to attempt to perform the calculations that we just performed for all the items in a large inventory. There is, however, a short-cut method of determinina an economical order point. It can be used whenever the shortage cost and the cost of overage are linear over the entire range of stocking choices. Perhaps this situation is prevalent in the area of low-demand insurance stocks.

It can be shown algebraically in such cases that the least cost reorder point is represented by the following notation:[4]

$$P(Z < J) < \frac{Ku}{Ku + Ko}$$

Where:
$P(Z < J)$ = Probability that demand will be less than some particular serial unit.
Ku = Shortage cost
Ko = Cost of overage

The best reorder point can be selected by the following steps:

1. Determine (a) the cost Ko that results from stocking one unit that will not be issued and (b) the cost Ku that results from the failure to stock one unit that was needed.

2. Compute a "critical ratio"--$\frac{Ku}{Ku + Ko}$.

3. Find the last value of J for which the $P(Z < J)$ is less than the critical ratio.

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[4]*Ibid.*, p. 87.

In our example, the critical ratio is:

$$\frac{Ku}{Ku + Ko} = \frac{\$1.50}{\$1.50 + \$\ .50} = .75$$

Looking down the list of values in the column headed $P(Z < J)$ in Table I, we see that .65 is the highest value in which the probability is less than the critical ratio. This value applies to serial unit number four. We therefore conclude that the most economical reorder point for this particular item is four units. The result also agrees with our computations of the best reorder point in Table II.

Some interesting observations can be made if one considers the critical ratio formula carefully. Perhaps some of these observations are rather obvious, but it would appear that any personnel responsible for setting inventory service goals should be completely familiar with the cost implications.

1. Any attempt to provide 100% supply availabilities--already generally recognized as prohibitive from an investment standpoint--would be justified only if there were no cost penalties associated with carrying too much stock. Conversely, if there were no penalties associated with a shortage or if the critical ratio were at least as high as the probability that zero units of stock would be demanded, there would be no economic justification to carry any stock of that item.

2. When the cost of overage and the shortage cost are equal, no

safety stock can be justified on economic grounds alone. The critical ratio of .50 obtained in such a case would indicate that only an amount of stock equal to the average demand over lead time should be considered.

3. A shortage costs that is double the cost of overage would allow us to protect against only two thirds of the possible demands over lead time.

4. Shortages costs four times the cost of overage would justify a service policy of just under 80%. A 90% service policy would require that the shortage cost be more than nine times greater than the cost of overage.

Figure 2 is a graphical presentation of the ratio of a single item's shortage cost to its cost of overage (not the critical ratio) related to the approximate inventory service levels that can be justified on economic grounds.

3. Estimating Demand Distributions

It was mentioned previously that mechanized supply activities have a general capability to predict an item's demand distribution. Manual activities do not. The vast amount of hand calculations that would be required to compute mean or standard deviations to determine demand distributions for all items of stock would be prohibitive. Schlaifer offers a simple method of estimating the demand distribution

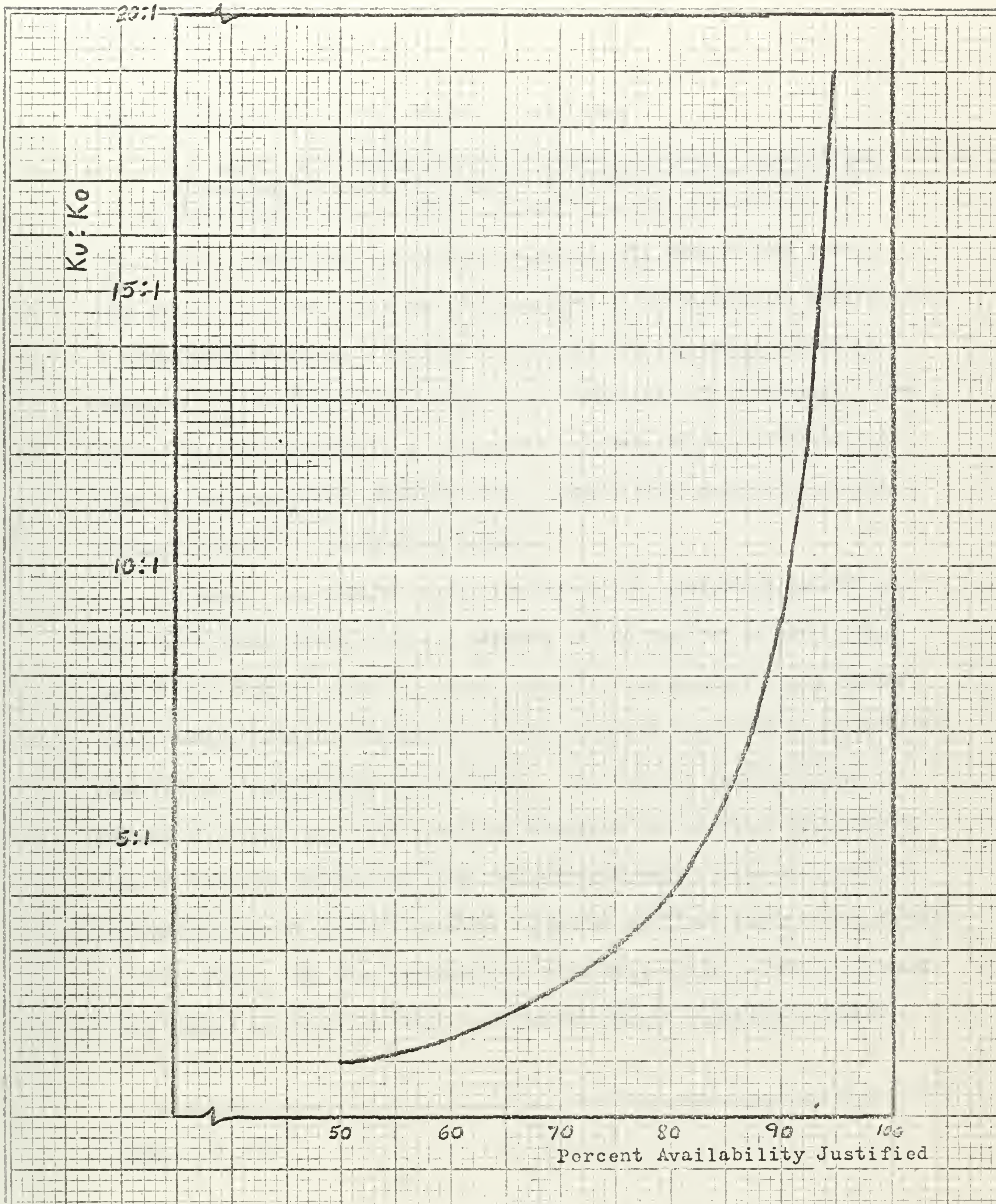

Figure 2

RATIO OF SHORTAGE COST (Ku) TO COST OF OVERAGE (Ko)

REQUIRED TO JUSTIFY STOCK AVAILABILITY

that may be useful at such manual activities.

> If a sample of n observations is drawn from some distribution and arrayed in order of size the kth observation is a reasonable estimate of the $\frac{K}{(n + 1)}$ fractile of the distribution.[5]

This merely means that if the last nine monthly demands for some particular item are observed, the smallest of those monthly demands is a reasonable estimate of the 1/10 fractile (representing 10% of the cumulative distribution) of that item's distribution of demands. The second smallest demand is a reasonable estimate of the 2/10 fractile (20% of the cumulative distribution). The seventh smallest would represent 70% of the cumulative demand.

To obtain a graphical presentation of the cumulative demand for some particular item, the past demands can be plotted on graph paper and a less than or equal to curve fitted to the points. As a matter of interest, a normal demand distribution would appear as an "S-shaped" cumulative distribution on the graph. The correct reorder point or number to stock over lead time, to integrate our previous discussion, can be found by proceeding from the vertical axis scaled in terms of probability or relative frequency along the critical ratio value to the plotted curve. We then proceed down from that point to the horizontal axis scaled in units of stock to find the "best" quantity to carry.

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[5]Ibid., p. 112.

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But it appears that plotting a curve would not be required in a large number of cases, particularly if we were dealing with items that had a small range of demands. Instead, the correct values could be mentally computed.

To investigate the potential of such a method for estimating a demand distribution, the writer generated five random samples of nine months demand each from a distribution similar to that contained in Table I. These demands are presented in Table III. Note that for an item with a critical ratio of .75, the reorder point for each group would be the seventh rank ordered demand:

$$\frac{K}{n+1} = \frac{7}{9+1} = .70$$

The probability that demand will be less than or equal to the seventh rank ordered number is .70 and this is the largest cumulative probability of a whole number that is less than our previously computed ratio of .75. Using these estimates, we would have set our reorder points at five, four, four, three, and four respectively, for the five samples. This compares reasonably well with the reorder point of four that we computed for this demand previously with the actual demand known.

The first two of these random generations of demand are plotted in Figure 3 to allow a visual comparison with the "true" demand for this item.

It would seem that, at least for material with reasonably constant

Table III

Estimates of Cumulative Demand Distributions

Based Upon Rank-Ordering Recorded Demands

Fractile Estimate	RANK ORDERED SAMPLES* #1	#2	#3	#4	#5
.10	2	0	0	0	0
.20	2	1	1	1	0
.30	2	2	2	2	0
.40	3	2	2	3	0
.50	3	3	2	3	2
.60	4	3	3	3	3
.70	5	4	4	3	4
.80	6	4	4	5	5
.90	6	4	5	6	6

*All five samples were randomly generated from the same probability distribution shown in Table I.

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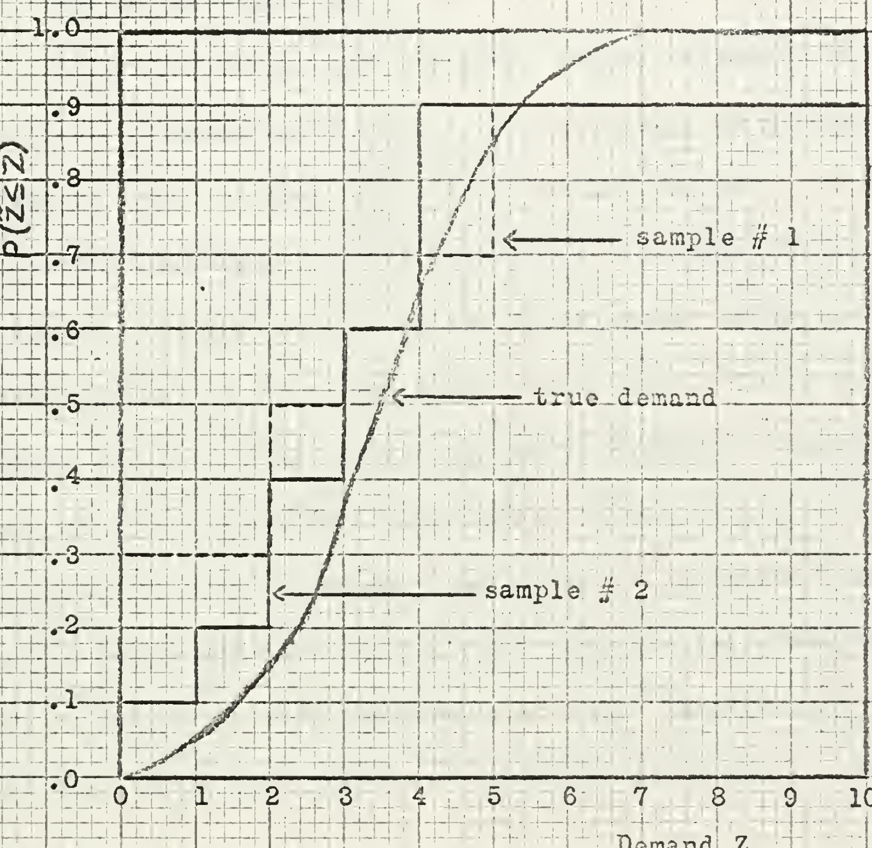

Figure 3

COMPARISON OF THE TRUE CUMULATIVE DEMAND DISTRIBUTION
WITH ESTIMATES OF DEMAND FROM TWO RANK ORDERED SAMPLES

demand, this method of estimating demand distributions would allow some application of a variable safety stock program at manual supply activities.

4. Cost Considerations

> The cost of a shortage is always composed of intangible elements as well as tangible which make the estimation of shortage cost even more difficult than the estimation of order cost or holding rate.[6]

The writer can accept the above quoted statement as a fact. Nevertheless, it seems worth trying if we are ever to reverse the current downward trend in Navy Stock Fund working capital. It should be noted that early attempts by Navy activities to implement Wilson-type EOQ formulas resulted in some rather questionable order cost and holding cost figures. Some of the order costs used in these formulas at different activities varied from \$5.40 to \$725.00.[7] Needless to say, many of these activities were forced to reduce the order quantities computed in such a haphazard manner by an arbitrary factor to stay within budgetary constraints. But such earlier attempts did pave the way to selective item management at these locations by pointing out the line items that, from an economical standpoint, required manage-

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[6]James W. Pritchard and Robert H. Eagle, Modern Inventory Management (New York: John Wiley and Sons, Inc., 1965), p. 143.

[7]Frank N. Wordon, "The Parameters of Inventory Management Decisions" (Unpublished Master's Thesis, George Washington University, 1963), p. 17.

ment attention.

Also like the values for holding costs and ordering costs in EOQ formulas, shortage costs and the costs of overage need not be precise in a critical ratio to yield workable results. The reader is reminded of the earlier discussion of the critical ratio of .75 where:

$$\frac{\text{Shortage Cost}}{\text{Shortage Cost + Holding Cost}} = \frac{\$1.50}{\$1.50 + \$.50} = .75$$

For the particular demand distribution that was used in Table II, any critical ratio between .65 and .85 would have yielded the same most economical reorder point of four. A shortage cost of $1.01 and a cost of overage of $.50 yields a critical ratio of .66. Using a shortage cost of $2.80 vice $1.50 would have also kept us within the .66 to .85 range. The point is that cost perameters need not be perfect to yield beneficial results.

It seems appropriate to turn to the field of managerial economics for an examination of the cost parameters involved in either a shortage or overage of material. There is an important difference between the costs that an economist recognizes and those that are reflected in accounting records. An accountant is generally concerned with the allocation of all expenses in an organization to some end product for profit and loss computation. In contrast to an accountant, it can be said that an economist is concerned only with any sacrifices that are made.

> The cost involved in any decision consists of the sacrifices of alternatives required by that decision. If there are no sacrifices, there is no cost.[8]

One basic idea in the so-called field of managerial economics is that the definition of costs must be adapted to the particular decision at hand. Clearly, this does involve judgment and may lead to varying conclusions from different people. A careful analysis of the situation, however, can often reduce these variances to an acceptable range.

Table IV, a summary of economic cost concepts, is intended to establish a frame of reference with the reader in discussing the costs that are appropriate for the decision at hand. One writer's comments regarding the ordering costs and the holding costs in EOQ formulas that "such data as have been generated have been summarily rejected as a basis for justifying budget requirements by both the Department of Defense and Bureau of the Budget..."[9] seems to indicate the need for such a benchmark.

It will help in the following discussion if we assume that (1) all supply activities currently operating will continue to do so and (2) there will be a considerable range and depth of stock on hand at all times.

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[8] W. W. Haynes, Managerial Economics--Analysis and Cases (Homewood, Illinois: The Dorsey Press, 1963), p. 31.

[9] Wordon, op. cit., p. 61.

Table IV

Various Cost Concepts Important in Economic Decisions

Concept	Its Antithesis	Purpose of Distinction
Implicit Costs	Explicit Costs	To assure full recognition of opportunity costs whether or not explicitly recognized in the formal accounting records.
Variable Costs	Fixed Costs	To separate costs that vary with increased or decreased volume from those that do not.
Incremental Costs	Sunk Costs	To separate those costs that will be affected by a decision from those that will run on as before.
Long-Run Costs	Short-Run Costs	To assure recognition of both, and emphasis being given the most relevant.

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With these concepts and assumptions in mind, the various factors that make up shortage and overage costs will be discussed.

At first blush, one might list the following factors as contributing to a shortage cost:

1. The cost to the consumer of a delay in delivery.
2. Salaries of personnel that must place an interim order.
3. The cost of transmitting an order.
4. The salaries of warehousing personnel at the supplying activity.
5. Transportation costs.
6. Salaries of receiving personnel.

Of these items, the cost to a customer of a delay in an item's delivery is the most difficult to measure. Such a cost would depend upon circumstances that only a local activity could determine. But what if the material were available from local commercial sources or could be furnished in a matter of a short time from some other supply activity? The incremental cost in the first case would be the difference in price between the Navy Stock Fund standard price and the dealer's price. In the second case, if material were delivered approximately as soon, there would possibly be no cost or delay to the customer involved.

Salaries of ordering, warehousing, and receiving personnel, it is suggested, are fixed costs. Personnel ceilings at supply activities are financed from operations and maintenance or military personnel

appropriations. Both the ceilings and the appropriations are largely independent of inventory management policies. If there were a tremendous increase in orders (if a critical ratio service system were adopted) the costs involved would be the value of functions that were given up by shifting personnel to the job of ordering.** Until proven otherwise, it would seem appropriate to assume that no vast change in workload would take place and there would be no increased costs in these functions.

Communications expenses also appear to be fixed. Stock points are now utlizing a rapid data transmission network to pass requisitions on to report transactions. Any change in the number of individual transmissions would not affect the cost of communications.

The cost of transportation should be limited to the difference between "normal" transportation charges and the premium transportation to be utilized in obtaining priority shipments if materials were not on hand when needed.

The costs of overage can be analyzed in a similar manner. It is suggested that there would be no increase in the number of warehousing personnel, security or janitorial expenses, or in the cost of heating or lighting a warehouse to accommodate material that was not issued in a normal procurement cycle.

The costs that do seem to be affected by a stocking decision are:

1. An interest charge on the inventory investment.

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2. The expected cost of obsolescence.

3. Physical deterioration of stock.

The interest charge is the easiest to compute. The Department of Defense has specified that an interest rate of four percent[10] will be used for inventory management purposes. Some might argue that this charge should be higher to reflect what these dollars would earn if they were not collected in taxes. One DSA activity, for example, used a 14 percent "time preference rate"[11] in their EOQ formulas to reflect the average rate of return on investment in the American economy. This writer, as a regular purchaser of savings bonds, can rationalize and accept the four percent rate that is specified.

The risk of obsolescence can roughly be determined by using the reciprocal of the expected useful life of an item, or in the case of a spare part, of its major equipment. For example, the obsolescence charge for an item with an expected life of 10 years can be estimated as 1/10 or .10.

Our intuition should tell us that the charge for deterioration would be very small for most items. Supplies with a definite shelf life would be relatively easy to assign a charge for deterioration to.

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[10] U.S. Department of Defense, "Peacetime Operating and Safety Levels of Supply", DOD Instruction 4140.11 of 24 June 1958.

[11] U.S. Department of Defense, Defense Supply Agency, DSA Material Management System Requirements Study, July 1963, p. 75.

What we have come up with so far in determining the cost of overage is really the same "cost to hold" that is used in EOQ formulas. Of course, we have eliminated some costs as fixed that many businesses do (and should) include in this rate.

This holding cost should be tempered for the amount of time that an item is subject to being in an overstocked position, namely once in an order cycle. For items that are ordered on an annual basis, we run the risk the whole year that the last item or the last few will not be demanded after reaching the reorder point. If the order cycle is quarterly, only one fourth of the annual holding cost should apply since the period of risk is shorter.

5. A Model

To be realistic, it must be admitted that the cost of a delay in the delivery of an item to a customer cannot be determined very accurately in most cases. There is still a wide range of locally procurable items that would involve no such cost. There are also numerous expensive but lightweight repair parts that could be delivered from another supply activity with no appreciable delay. It is suggested that the other costs involved can be estimated accurately enough to provide a useful solution to the problem of how much safety stock to hold when no cost of delay is involved.

A decision on whether to stock an item at a local activity can be

made using this critical ratio. If a repair part, for example, has a probability of .64 that one or more units will be demanded, then the probability that less than one unit will be demanded is .36. A critical ratio of .33 for this item would indicate that it cannot economically be stocked at the local activity.

A decision can also be made for the correct amount of safety stock to hold for items that obviously should be stocked because of past usage. A critical ratio of .50 or less for these items would indicate that no safety stock is justified and the reorder point should only consider the demand over lead time.

The most economical reorder point to set is where:

$$P(\text{demand}) \quad \frac{1C}{1C + \left(SP \times \left(\frac{HC}{Qm}\right)\right)}$$

where:

1C = incremental cost of transportation or purchase price
SP = standard NSF price
HC = holding cost
Qm = Order quantity in months of stock (or simply 1.0 in the case of an insurance item)

Considered in the light of all other factors being equal, we make the following observations.

1. An extremely low price for an item will make the "denominator" of our "critical ratio" small and justify larger safety stocks.

2. A heavy, bulky item will cause the "numerator" to become large because of transportation charges. This also supports larger safety stocks.

3. An extremely high unit price for an item would decrease our justification for safety stocks considerably.

4. A relatively light and compact item would mean that less safety stock would be justified.

5. A high obsolescence rate would lower safety levels. When one considers the vast differences that exist in individual items of Navy Stock Fund material, a safety level policy that assumes a number of characteristics to be equal for all items should probably be questioned by the budgeteers.

> Prerequisite to the design of inventory management systems and sub-systems is a detailed and thorough study of the characteristics of the individual line items that make up the total inventory. Unfortunately, item analysis invariably reveals the inventory to be not one large homogenious group of items, but a number of homogenious groups, each of which for management purposes bears little relationship to the other groups...
> Whatever the groups, a study must be made of each to determine optimum management policies for each group. Then a determination must be made to establish those policies which can be applied in common to a majority of the groups and those applicable to only a specific group. At this point the structure of the selective management concept becomes clear.[12]

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[12] _Ibid._, p. 3.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1. Summary

After proving its practicality and efficiency in the area of common-use commodities for more than fifty years, the stock fund concept of supply was significantly expanded some eight years ago to include such slow-moving items as repair parts. It was realized at that time that obsolescence and pricing problems would be encountered and that stock turn would be slow for these items. The advantages of stock funding, however, were considered to outweigh those shortcomings.

Recent reductions in cash, coupled with the requirements of supporting increasingly complex and expensive equipment, have resulted in a serious financial problem for the fund. Local activity inventory investment in many material cogs is currently limited to two and a half times the monthly value of issues. Throughout the whole system, procurement funds are too limited to support new programs, replenish issued material, and provide the level of supply availability that the managers of the Navy Stock Fund deem desirable. The reduction of working capital can be attributed to three recent developments:

1. A vast amount of money has been diverted since the mid-1950's from "excess" operating capital through the reapportionment progress to other programs and uses (to other appropriations).

2. The capitalization of repair parts into the stock fund in 1957 created problems in obsolescence and pricing. Annual operating losses since that date have been significant.

3. Transfers of money and material to the newly established Defense Stock Fund in 1962 and 1963 caused an immediate loss of cash as well as future sales.

The central issue in current financial problems appears, however, to be associated primarily with the large inventory investment required to provide a high level of repair parts support for today's complex equipments. The relatively unpredictable demand for these items, coupled with a decentralized stocking policy, requires a considerable amount of safety stock. The resulting stock turn ratio for this segment of stock fund inventories is much lower than the Department of Defense budget analysts consider satisfactory.

An apparent need is some method of determining, on an economic basis, the level of support that can be justified. A possible approach to this problem was discussed by the writer.

2. Conclusions

Traditionally, improvements in inventory management techniques have been made in times of adverse conditions. In this respect the current financial situation of the Navy Stock Fund may not be all bad. Great strides have recently been made in the area of selective item

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management. Variable stock level programs, for example, have shown that, by concentrating attention upon the single characteristic of each line item's annual dollar demand, significant reductions in inventory investment can be made without adding to the current workload. Such improvements are not always a blessing, though. Management improvements gained through a reduction in working capital tend to cause anticipations of even greater advancements if funds are further reduced. This effect is no doubt magnified by an urgent need of funds for other programs.

In addition, there is apparently a widespread belief at higher budgetary levels that the current investment in safety stocks for slow-moving repair parts is both unproductive and unjustified. Reductions in working capital are felt in this segment of the stock fund first, since the replacement of fast-moving stocks is mandatory. The funding of repair parts for new programs and for replacing issued materials in this area has been significantly below what inventory managers would have desired in recent years. Working capital reductions, it is concluded, are but control devices used to reduce both the range and depth of Navy Stock Fund coverage in repair parts.

There is the added factor of obsolescence losses, attributable primarily to the inclusion of repair parts into stock fund inventories, that threatens the revolving concept of the fund and adds incentives to further reduce investments in insurance stocks.

The higher level budget analysts, however, are considered to have

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good reason to question the need for such a large investment in repair parts inventories. No concerted attempt has apparently ever been made to determine an optimal level of supply availability that should be provided for the various categories of material that are included in stock fund inventories. The Navy's policy of stocking all items with possible demand in decentralized locations near the ultimate consumers is also questionable from an economic standpoint.

In short, it is concluded that further reductions will be made in Navy Stock Fund working capital. Lacking any economic basis to "prove" what safety levels of stocks should be at local activities, inventory managers can expect an "across the board" reduction in stock availability in the future.

3. Recommendations

1. Efforts should be made to determine on an economic basis optimal safety levels for the various "groupings" of material in the Navy Stock Fund.

Just as annual dollar demand pointed the way to reducing the investment in operating levels, other item characteristics appear to be the determinants of safety stock levels. Treating all other factors as equal except unit demand and annual dollar demand fails to consider whether the same item or an acceptable substitute can be locally purchased, the expected additional transportation cost of an interim requisition,

or the obsolescence risk involved. Certainly all stock fund items are not as homogenious as the current methods of computing reorder points would imply.

2. The Navy's policy of decentralized storage for high cost, low demand repair parts should be reviewed.

If adequate transportation arrangements can be secured that would provide prompt delivery of requested parts from a centralized location, it would appear that significant reductions of repair parts inventories could be made. Item characteristics of demand, unit price, and weight and cube should be the important factors to consider in such a study.

3. A variable stock level program similar to the FMSO VSL program should be developed for manual supply activities.

Non-mechanized activities are currently operating under a severe handicap. Functions that were once handled by Navy ECP's have been imposed upon these activities at the same time that inventory investment levels were being reduced. Manual activities, lacking the resources to cope with such problems, are in need of a centrally developed selective item requisitioning system (EOQ) that will permit reducing inventory investments without increasing workload. Consideration should be given to establishing a central servicing organization to review the annual dollar demand data from these activities and provide them with tailored requisitioning guides for the operating portions of their inventories.

4. Studies should be conducted to determine the feasibility of estimating demand distributions at manual stock points by rank ordering historical demand data.

A fixed monthly safety stock policy has the disadvantage of protecting items with relatively constant demand to a greater extent than is necessary. Items with fluctuating demands are not adequately protected against stockout under such a policy. Conventional methods of determining demand distributions necessary to establish variable safety levels require entirely too many calculations for a manual activity to perform. Simulations with actual demand data are recommended to determine what effects the rank order method of estimating demands would have on investment levels and stock availability under various administratively assigned service goals. The results of these studies should be compared with the investment levels and supply availability performance of fixed-month safety stocks.

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